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16. Abstract

NHTSA inspected two Zoox vehicles under Audit Query 23001 to evaluate compliance with certain applicable Federal Motor Vehicle Safety Standards ("FMVSS"). This report documents apparent noncompliances with FMVSS Nos. 103, 104, 108, 111, 135, 201, 205, and 208.

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Background

In July 2022, Zoox, Inc. ("Zoox") announced that it had certified a purpose-built vehicle, designed to be primarily operated using an automated driving system, as being compliant with all applicable Federal Motor Vehicle Safety Standards ("FMVSS"). In September of that year, NHTSA sent Zoox a Special Order requiring information related to Zoox's basis for certification. After reviewing Zoox's response, which included the fact that Zoox classified its vehicle as a passenger car, in March 2023, NHTSA opened Audit Query ("AQ") 23001 to more fully examine, among other things, the process and technical data on which Zoox relied when certifying the Zoox vehicle. In the course of that investigation, NHTSA noticed under 49 U.S.C. § 30166(b)(1)(A) the inspection that is documented in this report. Specifically, NHTSA notified Zoox that it intended to inspect a certified Model Year 2023 Zoox vehicle and a representative Model Year 2024 Zoox vehicle with respect to any FMVSS that apply to passenger vehicles, including by observing basic vehicle functioning.

NHTSA conducted the inspection on October 3, 2024 at Zoox's Las Vegas Sunset facility. This report describes the inspection and findings.

Attendees

NHTSA:

- Otto Matheke, Office of Enforcement
- Neil Dold, Office of Enforcement
- Dylan Voneiff, Office of the Chief Counsel

Zoox:

- Beth Mykytiuk
- Amanda Prescott
- Kyle Anderson
- Bobby Norton
- Greg Serrano

Equipment

NHTSA used the equipment listed in Table 1 during the inspection.

Table 1: Equipment list

Equipment	Identifier	Calibration status
Ruler	PEC262-006 6" RIGID RULE; S/N: 242410430	Date Calibrated: June 17, 2024
Calipers	Mitutoyo Digital Caliper Model CD-4" ASX; S/N: B24036303	Date Calibrated: March 25, 2024
Evidence scales	White 2" Adhesive Scales Evident Item #5088W	N/A
Masking tape	N/A	N/A
Camera	Apple iPhone 11	N/A

Overview of Zoox's purpose-built vehicles

NHTSA inspected two vehicles: a certified model year 2023 vehicle and a representative model year 2024 vehicle (which was not certified at the time of the inspection). These vehicles have many shared design attributes. The inspected Zoox vehicles are intended to be bidirectional – either end of the vehicle can be oriented for the forward direction of travel – and primarily driven by an automated driving system ("ADS"). According to Zoox employee statements made during the inspection, Zoox's design intent (and interpretation of the vehicle's operation) is that the vehicles generally do not go into reverse, and they cannot go into reverse when under manual control; instead, Zoox employees explained, Zoox designed the vehicle to change directionality from "north" to "south" or *vice versa* – i.e., the orientation of lighting and forward gear selection changes from one end of the vehicle to another. The vehicles do not have a steering wheel, pedals, or gear selection mechanisms installed within the occupant compartment. However, the vehicles can be controlled by a human-operated remote control in certain scenarios. Additionally, the ADS may receive remote assistance from a system that Zoox calls "TeleGuidance," which influences the ADS's behavior.

Zoox designates one end of the vehicle north and the other end south. NHTSA staff marked the vehicles with blue masking tape during inspection to emphasize the north ("N") and south ("S") side of the vehicles so that location of photographs and vehicle directionality can be easily observed (Figure 1).

Figure 1: Model year 2023 (left) and 2024 (right) Zoox vehicles. North side (N) blue masking tape marking visible.

The interior of each vehicle has four designated seating positions, two on each end of the occupant compartment. The seats face inward, are separated by a small arm rest, and each seating position has an outboard touch screen. Each seating position is equipped with seat belts and lower child restraint system anchorages.

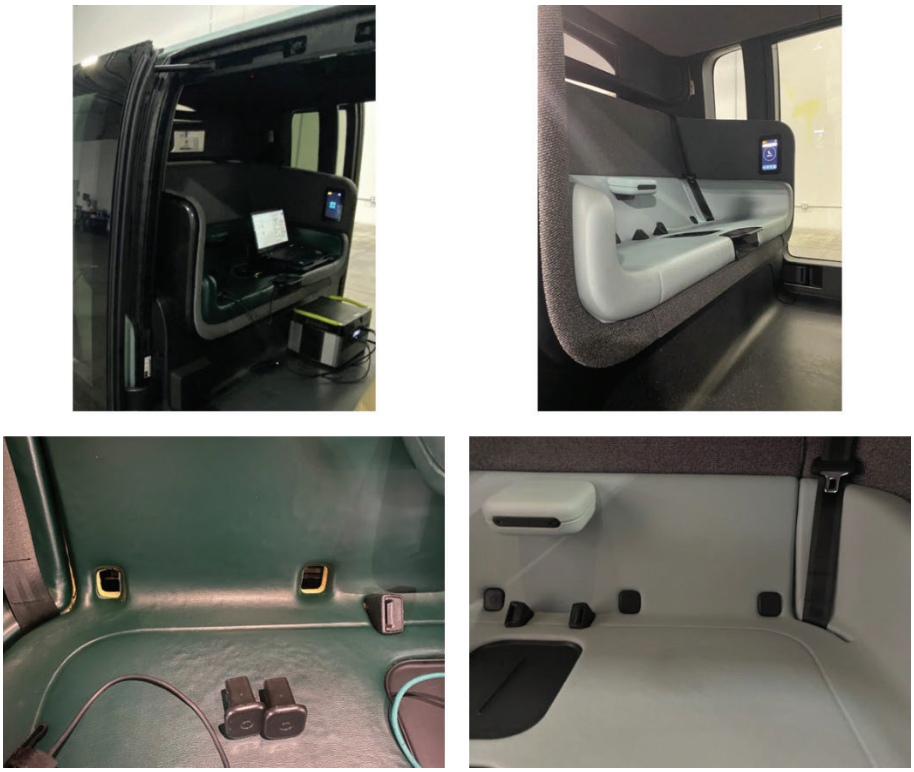

Figure 2: Interiors of 2023 (left) and 2024 (right) Zoox vehicles.

The Zoox vehicles were identified by their VINs during inspection, and labels were measured and photographed for each model year (Figure 3 and Figure 4).

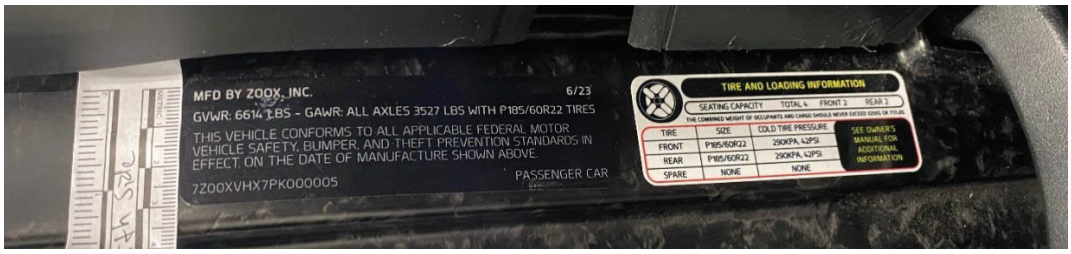

Figure 3: Model year 2023 Zoox vehicle certification and tire labels with adhesive scale.

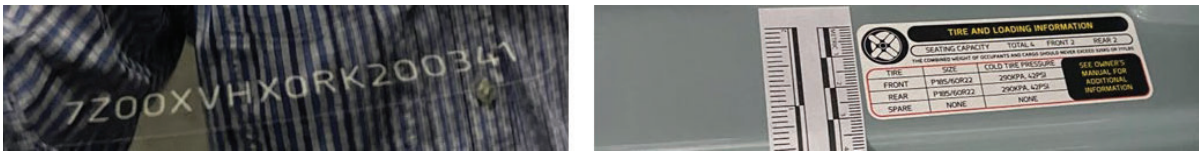

Figure 4: Model year 2024 Zoox vehicle window VIN label (left) and tire label (right) with adhesive scale.

Inspection approach

Each vehicle inspection was conducted in a nondestructive manner to evaluate readily observable compliance issues with basic demonstration of vehicle capabilities. The basic nondestructive inspection enabled NHTSA to evaluate apparent noncompliances; however, evaluation of all compliance requirements (especially requirements that would normally be evaluated in a destructive manner or via measurements on a test track) is not within scope of this report. The inspection of each vehicle:

1. Examined the interior and exterior of the vehicle, as well as associated motor vehicle equipment, to establish the presence or absence of required attributes;
2. Measured specific vehicle attributes to assist in evaluating compliance with certain requirements;
3. Examined or demonstrated certain basic vehicle functions to assist in evaluating compliance with certain FMVSS.

General certification requirements

49 U.S.C. § 30115 requires, among other things, that certification of a vehicle be shown by a label or tag permanently fixed to the vehicle. Further requirements for certification are established in regulation, including content and location requirements in 49 C.F.R. Part 567. Certification by a manufacturer includes certification to all applicable FMVSS (49 C.F.R. Part 571), bumper standards (49 C.F.R. Part 581), and federal theft prevention standards (49 C.F.R. Part 541). The inspection here focused on certain applicable FMVSS. Bumper standards were out of scope given the nondestructive nature of inspection, and theft prevention standards were out of scope because to the standard excludes certain vehicles based on production thresholds (*see* 49 C.F.R. 541.3(b)) making theft protection requirements inapplicable to the Zoox vehicles.

Within this document, FMVSS are referred to by the section number within Part 571 Subpart B (e.g., FMVSS No. 103 is 49 C.F.R. § 571.103). NHTSA's inspection observations are relevant to the applicability and compliance with specific standards that have clear criteria for evaluation via visual inspection. Applicability is assessed under 49 C.F.R. § 571.7, which states that each FMVSS "applies according to its terms to all motor vehicles or items of motor vehicle equipment," along with the text of the individual standards.

FMVSS Inspection Results

Zoox certified its model year 2023 vehicle as a passenger car (see certification label in Figure 1). Certain requirements applicable to passenger cars were assessed as described below for both model year vehicles. NHTSA focused the inspection on those requirements within each of the listed FMVSS where apparent compliance could be ascertained through visual inspection.

The inspection did not attempt to make findings on every applicable requirement, and certain FMVSS and individual requirements were omitted from the inspection. Apparent noncompliances that were observed for each model year during inspection are organized by FMVSS in the sections below. The absence of a particular requirement or standard in the list below does not indicate apparent compliance or noncompliance with the absent requirement or

standard. The FMVSS addressed in this report are FMVSS Nos. 103, 104, 108, 111, 135, 201, 205, and 208.

FMVSS No. 103, Windshield defrosting and defogging systems

FMVSS No. 103 applies to passenger cars (see paragraph S2).

Requirements and inspection overview

Paragraph S4(a) requires that "each passenger car shall meet the requirements specified in S4.1, S4.2, and S4.3.," subject to certain exceptions pertaining only to vehicles manufactured for sale in the noncontinental United States. Paragraph S4.1 states: "Each vehicle shall have a windshield defrosting and defogging system." Paragraphs S4.2 and S4.3 specify testable performance requirements that were not inspected since, among other things and as described below, each vehicle has an apparent noncompliance. NHTSA inspected the vehicle for the systems required under S4.1.

Inspection observations and apparent noncompliances

Based on inspection, each vehicle has an apparent noncompliance with 49 C.F.R. § 571.103 S4.1: Neither vehicle has a defrosting and defogging system.

Inspection of windshield areas on the north and south end of each Zoox vehicle revealed no systems available for windshield defrosting or defogging (Figure 5, Figure 6). Zoox's vehicle has glazing at each end of the bidirectional vehicle. Zoox has not equipped the model year 2023 or 2024 vehicles with a defrosting and defogging system as required under paragraph S4.1

Figure 5: Images of the windshield from the interior and exterior of the vehicle on the north (left) and south (right) ends of the 2023 Zoox vehicle.

Figure 6: Images of the windshield from the interior and exterior of the vehicle on the north (left) and south (right) ends of the 2024 Zoox vehicle.

FMVSS No. 104, Windshield wiping and washing systems

FMVSS No. 104 applies to passenger cars (see paragraph S2).

Requirements and inspection overview

Requirement S4.1 requires that all vehicles to which the standard applies have "a power-driven windshield wiping system" and requirement S4.2.1 requires that passenger cars "have a windshield washing system," with each system subject to requirements specified in the standard. NHTSA inspected the vehicle for the systems required under S4.1 and S4.2.1.

Inspection observations and apparent noncompliances

Based on inspection, each vehicle has an apparent noncompliance with 49 C.F.R. § 571.104 paragraphs S4.1 and S4.2.1. Neither vehicle has a windshield wiping system nor a windshield washing system.

Inspection of windshield areas on the north and south end of each Zoox vehicle revealed no systems available for windshield defrosting or defogging (Figure 5, Figure 6). Zoox has not equipped either end of either the model year 2023 or 2024 vehicle with a windshield wiping system or a windshield washing system.

FMVSS No. 108; Lamps, reflective devices, and associated equipment.

FMVSS No. 108 applies to passenger cars and certain lighting equipment (S3).

Figure 7: Model year 2023 Zoox vehicle annotated images showing device directionality with arrows pointing to same devices on top and bottom images. Top images: Vehicle configured with south side as forward direction. Bottom images: Vehicle configured with north side as forward direction.

Requirements and inspection overview

Because the Zoox vehicle is bidirectional and does not include certain motor vehicle controls consistent with a "front" or "back," NHTSA assessed requirements S8.1, S9.1.1, and S9.4 of Standard 108.

Paragraph S8 details requirements for reflex reflectors, which are defined in paragraph S4 as "devices used on vehicles to give an indication to approaching drivers using reflected light from the lamps of the approaching vehicle." Reflex reflectors are required on the rear of the vehicle (two red, mounted symmetrically about the vertical center line and as far apart as practicable) and on the sides of the vehicle (one amber and one red on each side, as far to the front and back as possible, respectively) (see S8.1 and Table I-a of the standard).

NHTSA inspected the Zoox vehicles for presence and location of devices that could be considered reflex reflectors. The 2023 Zoox vehicle employs side mounted lamps that change color depending on the direction of travel and rear reflex reflectors that are blocked by moving shields when the vehicle changes direction. (Figure 7, Figure 8).

NHTSA did not measure the photometry or physical performance of the devices under S8.1.11 or S8.1.12.

Paragraph S6.6.1 requires each passenger car to be equipped with a turn signal operating unit and a headlamp beam switching device (among other devices) that meet the requirements of S9, which include:

- S9.1.1 requires a turn signal operating unit "be self-canceling by steering wheel rotation and capable of cancellation by a manually operated control,"
- S9.4 requires "a means of switching between lower and upper beams designed and located so that it may be operated conveniently by a simple movement of the driver's hand or foot."

NHTSA inspected each vehicle for the presence of the manually operated controls required by S9.1.1 and S9.4.

Model year 2023 apparent noncompliances

Based on inspection, the model year 2023 vehicle appears to be noncompliant with FMVSS No. 108 requirements S8.1, S9.1.1, and S9.4.

The 2023 vehicle is equipped with red reflex reflectors on the north and south ends of the vehicle. These red reflex reflectors are covered and uncovered depending on which end of the vehicle is designated for forward travel. The vehicle is not equipped with reflex reflectors on the sides of the vehicle (Figure 9), and, therefore, lacks certain reflex reflectors required under S8.1 for passenger cars as listed in Table I-a.

Additionally, the vehicle is not equipped with a steering wheel and is not equipped with any available hand or foot operated controls that would enable compliance with S9.1.1 and S9.4.

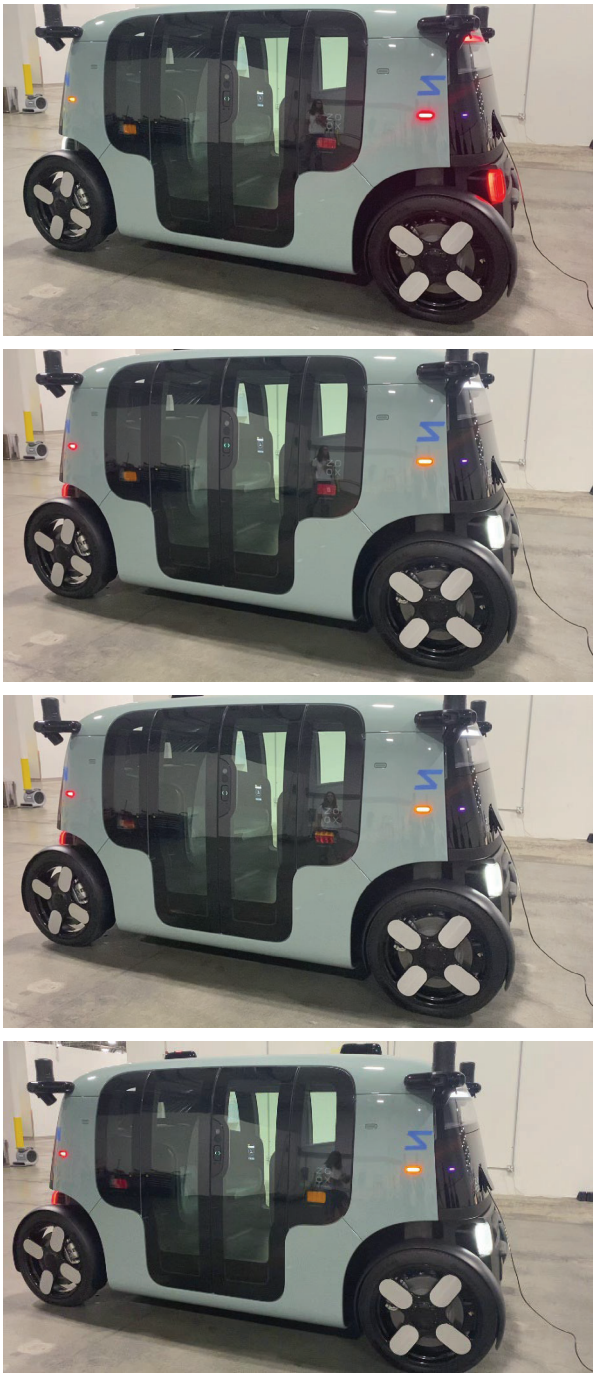

Figure 8: Model year 2024 Zoox vehicle showing sequence (top to bottom) of vehicle changing lamp colors and reflex reflector device rotation. Top shows northward facing forward direction and bottom is southward facing forward direction.

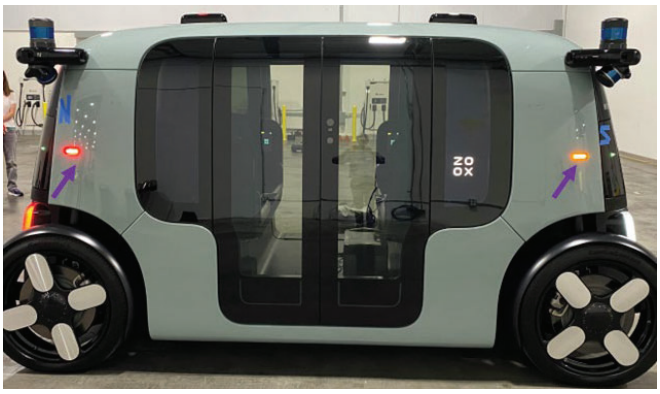

Figure 9: Model year 2023 Zoox vehicle side view, showing absence of side reflex reflectors. Arrows point to red and amber lamps on the side of the vehicle

Model year 2024 apparent noncompliances

Based on inspection, the model year 2024 vehicle appears to be noncompliant with FMVSS No. 108 requirements S9.1.1 and S9.4.

The model year 2024 vehicle can change lamp color and cover and uncover "front" and "rear" reflex reflectors in a manner similar to the 2023 vehicle. However, the 2024 vehicle is also equipped with side reflex reflectors on each side of the vehicle behind the glazing adjacent to the doors. Zoox demonstrated that the 2024 design includes ability to alter the side reflectors from amber to red (Figure 8). S8.1 is not identified as an apparent noncompliance for the 2024 vehicle because NHTSA's inspection found reflex reflectors on the sides and each end of the vehicle; however, a complete evaluation of compliance with S8.1 would require additional assessment beyond the scope of the inspection and this report.

FMVSS No. 111, Rear visibility

FMVSS No. 111 applies to passenger cars, multipurpose passenger vehicles, trucks, buses, school buses, motorcycles and low-speed vehicles (see paragraph S3).

Requirements and inspection overview

The requirements of FMVSS No. 111 applicable to passenger cars are those in paragraph S5 of the standards. These requirements stipulate that each passenger car shall have "an inside rearview mirror of unit magnification" (S5.1), "an outside mirror of unit magnification" (S5.2.1), and "a rearview image," each of which must meet certain performance requirements (S5.5(b)). A rearview image is defined in the standard (S4) as "a visual image, detected by means of a single source, of the area directly behind a vehicle that is provided in a single location to the vehicle operator and by means of indirect vision." In general, motor vehicles use a single camera whose image is displayed on a screen within the vehicle for purposes of compliance with the rearview image requirements.

NHTSA inspected each vehicle for the required mirrors and rearview images.

Inspection observations and apparent noncompliances

Based on inspection, each vehicle has an apparent noncompliance with requirements S5.1, S5.2.1, and S5.5. Neither vehicle is equipped with interior mirrors, exterior mirrors, nor a system that would meet the definition of a rearview image.

Although each vehicle has a color touchscreen display adjacent to each seating position and exterior cameras, no rearview image from a single source is displayed within the vehicle meeting the requirements under S5.5 and its subparagraphs.

FMVSS No. 135, Light vehicle brake systems

FMVSS No. 135 applies to "passenger cars manufactured on or after September 1, 2000" (S3).

Requirements and inspection overview

The standard requires each vehicle to be equipped with a service brake system (S5.1) and a parking brake system (S5.2). The standard requires that "[t]he service brakes shall be activated by means of a foot control" and the separate parking brake control "may be either a hand or foot control" (S5.3.1).

NHTSA inspected each vehicle for a service brake foot control and the parking brake hand or foot control. None were observed.

Inspection observations and apparent noncompliances

Based on inspection, each vehicle has an apparent noncompliance with the control requirements in S5.3.1.

The vehicles do not have any foot operated controls. The vehicles' hand operated controls are limited to functions that are unrelated to braking (e.g., interior lighting switches, temperature controls on the touchscreens). Consequently, each vehicle lacks a service brake and parking brake that can be manually controlled as required.

FMVSS No. 201, Occupant protection in interior impact

FMVSS No. 201 applies to passenger cars (S2).

Requirements and inspection overview

The standard specifies requirements for instrument panels, seat backs, interior compartment doors, sun visors and arm rests (S5). NHTSA's inspection focused on sun visors because sun visors are required at each front outboard designated seating position (S5.4.1).

Inspection observations and apparent noncompliances

Based on inspection, each vehicle has an apparent noncompliance with the sun visor requirements in S5.4. Sun visors are not installed at any designated seating position in either vehicle.

FMVSS No. 205, Glazing materials

FMVSS No. 205 applies to passenger cars (S3(a)).

Requirements and inspection overview

FMVSS No. 205 specifies requirements (S5) for glazing materials. This is accomplished in part by incorporating the ANSI/SAE Z26.1-1996 standard by reference. Additionally, the glazing markings according to the ANSI/SAE standard must be certified either by the glazing manufacturer or the entity that cuts the glazing material. NHTSA's inspection focused on the window glazing markings on each Zoox vehicle to determine if the markings indicated appropriate materials were used in each position.

The requirements in ANSI/SAE Z26.1-1996 are organized in Section 4 of the ANSI/SAE standard by "Items" that specify acceptable locations for use and requisite tests that each item must meet. Section 7 of the ANSI/SAE standard specifies that markings include "the words American National Standard or the characters AS" followed by the alphanumeric characters indicating the set of tests – i.e., the item from section 4 – that the glazing meets. For example, glazing meeting the criteria from *Item 1* is marked as AS1, and the AS1 mark indicates that it can be used anywhere in a motor vehicle, including windshields. AS1 marked glazing is the only glazing specified in the ANSI/SAE standard for windshield use on passenger cars.

Inspection observations and apparent noncompliances

Based on inspection, each vehicle has an apparent noncompliance with the requirements for windshield glazing from ANSI/SAE Z26.1-1996 incorporated by reference in S5.1.

Figure 10: Glazing markings from each vehicle's windshield, door, window adjacent to door, and roof. Top: Model year 2023. Bottom: Model year 2024. Photos taken from exterior of vehicle, except for roof which was taken from interior.

Each vehicle had glazing at the same locations, but glazing markings differed between model year (Table 2, Figure 10). Each windshield was marked with AS4, which is the marking for Item 4 in ANSI/SAE Z26.1-1996. This item specifies that AS4 glazing may only be used in

specifically listed locations in a motor vehicle. Windshields are not among the listed locations. Therefore, the glazing on each end of the bidirectional vehicle appears to not comply with S5.1 of Standard 205.

Table 2: Markings by model year and location.

Model year	*Windshield*	*Door*	*Window adjacent to door*	*Roof*
2023	AS4	AS2	AS2	AS3
2024	AS4	AS16B	AS2	AS3

FMVSS No. 208, Occupant crash protection

FMVSS No. 208 applies to passenger cars (S3(a)).

Requirements and inspection overview

The inspection for FMVSS No. 208 focused on certain requirements related to telltales and labels for air bags because these requirements can be assessed without destructive testing.

Telltales and indicators related to air bags are specified within several requirements including S7.3 and S19.2.

- Paragraph S7.3 specifies a seat belt warning system for the driver's seat that meets certain audible and visual requirements.
- Subparagraph S19.2.2 specifies requirements for a yellow telltales "for each front outboard passenger seat" with the words "PASSENGER AIR BAG OFF" or "PASS AIR BAG OFF" that emits "light whenever the associated front outboard passenger air bag system is deactivated and does not emit light whenever the associated front outboard passenger air bag system is activated, except that the telltale(s) need not illuminate when the associated front outboard passenger seat is unoccupied."

Warnings and disclosures are required to be displayed on labels installed in vehicles and within owner's manuals under S4.5.1.

- Requirements in S4.5.1(b) include a label affixed to the vehicle's sun visor that conforms to specific content listed in certain figures or subparagraphs within the standard.
- S4.5.1(b)(4) permits a manufacturer to request additional design specific information be authorized by the NHTSA's Administrator.
- Additional labels may be required to be affixed to sun visors under S4.5.1(c) and to the dashboard under S4.5.1(e) depending on compliance circumstances.
- For the above label requirements, the standard specifies particular language, message area minimum sizes, (30 cm^2 for the sun visor label required in S4.5.1(b) and 20 cm^2 for the label specified in S4.5.1(c)) and pictograms. Absent an authorized exception or exemption, the minimum required labels are required to state: "See owner's manual for more information about air bags."

- S4.5.1(g) also requires that additional air bag labels not "cause confusion or contradiction" with the required sun visor label and that they "shall be expressed in symbols, words and abbreviations required by this standard [FMVSS No. 208]."

During the inspection of the two vehicles, NHTSA did not inspect vehicle owner's manuals for compliance with the requirements under S4.5.1(a) or S4.1.5(f), which establish requirements to include certain air bag maintenance and system function information in the owner's manual.

Inspection observations and apparent noncompliance

Based on inspection, each vehicle has an apparent noncompliance with the requirements for air bag warning labels specified under S4.5.1.

Inspection of telltales, indicators, and labels found that the vehicles were equipped with seat belt warnings and yellow passenger air bag telltales at each seating position on an outboard touchscreen display, as well as air bag warning labels (Figure 11).

Figure 11: Air bag telltales and warning labels in model year 2023 (top) and 2024 (bottom) vehicles. Photos are representative of the four displays and four labels in each vehicle, with the displays and labels located outboard of each designated seating position.

As discussed above and as related to FMVSS No. 201, the vehicle is not equipped with the sun visors required by FMVSS No. 201. Therefore, it also does not have the labels required to be affixed to sun visors under FMVSS No. 208 S4.5.1(b). Each vehicle had four identical air bag warning labels, located outboard and to the rear of each seating position (Figure 11). The air bag warning labels contain a pictogram that does not conform to any of the pictograms contained within FMVSS No. 208, and the labels contain a statement about the "ZOOX APP," which are words that are not specified by the standard. No air bag label mentions the owner's manual. Consequently, the label appears to not conform to S4.5.1(g) because it uses words and symbols that are not specified in the standard.

Certification label observations (49 C.F.R. Part 567)

NHTSA inspected the model year 2023 vehicle for adherence to 49 C.F.R. § 567.4. The representative model year 2024 vehicle was not certified by Zoox at the time of inspection, and no certification label was affixed to the vehicle. Observations below pertain to the model year 2023 vehicle:

- Certification labels are affixed in each door jamb of the Zoox vehicle. Requirements for location are established at 49 C.F.R. § 567.4(c), which relate to the driver's seating position, "or if none of these locations is practicable, to the left side of the instrument panel." The same requirement also provides for a means to submit "drawings or photographs showing a suggested alternate location in the same general area" to NHTSA for approval. The Zoox vehicle does not have a driver's seating position and the label is not "to the left side of the instrument panel," and Zoox did not notify NHTSA of its intended label position and request approval under the procedure established in 49 C.F.R. § 567.4(c).
- The Zoox vehicle's certification labels' content appeared to meet content requirements for lettering contrast (49 C.F.R. § 567.4(f)), capitalization, and size (49 § C.F.R. 567.4(g)) when observed and measured. Accuracy of variable content (e.g., weight ratings, dates) was not evaluated.
- The two labels were not evaluated under 49 C.F.R. § 567.4(b)'s permanency requirements because NHTSA's inspection was nondestructive.